Outlines of Field Trips in Geology for Central Ohio

By

Charles S. Prosser

and

William Clifford Morse

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OHIO STATE UNIVERSITY

Columbus, Ohio
The College Book Store
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INTRODUCTION.

These outlines have been developed from the courses in field geology which the writer has given during the last ten years in Ohio State University. Similar ones adapted to the local geology were given by him at an earlier date in Union College, Washburn College and Cornell University. The selection and arrangement of topics in these outlines have been made very largely by Mr. Morse who as a former student in this course and later as a teacher has become well acquainted with the localities described.

The reference lists, which are fairly complete, have been selected mainly by the writer and have been in use for several years. The entire lists are intended only for those students who take up this work quite thoroughly as, for example, those in course No. 105, but it is hoped that other students will look up the most important references for each trip which are indicated by the * mark. An essentially complete "Bibliography of Ohio Geology" down to its time of publication may be found in Bulletin No. 6, 1906, of the Geological Survey of Ohio. It is also urged that each student provide himself with a copy of the 1909 Geological Map of Ohio and Bulletin No. 7 of the Geological Survey of Ohio which contains the revised nomenclature of the Ohio geological formations. These publications may be obtained at the office of the Geological Survey in Orton Hall.

In the college of Arts, Philosophy and Science, because instruction in physiography, inorganic and economic geology is given in other courses by different members of the department of geology, the course called Field Geology (formerly known as No. 13) has been confined mainly to stratigraphic geology and the fossils found in the various formations studied.

In the course in general geology in the colleges of Engineering and Agriculture and Domestic Science some attention has been given to physiography because these students receive no instruction in this subject in any other course in the University, and to economic geology because this has been given in the winter when the weather in this latitude is unfavorable for field trips. The large number of students in these courses, particularly at present, due in part to the change from the term to the semester plan, renders it impossible to give each student as much individual attention as formerly and it is hoped that these outlines may supplement the present personal instruction to such an extent that as satisfactory results may be secured as in the past. They are intended primarily for students in the several courses in general geology, Nos. 152, 165 and 168, in the Agricultural and Engineering Colleges and for the course in historical geology, No. 104, in the Colleges of Education and Arts.

The natural advantages for the field study of stratigraphic geology in central Ohio compare favorably with those adjacent to most of the larger universities of this country. In course 13 in former years the class studied in the field at least twenty of the thirty or more geological formations of Ohio. Columbus is a center for steam and electric railways and on this account the class was able to study all these formations without being absent a single night from the city. The trips, as a rule, were made on Saturdays, leaving in the morning and returning in the evening, and by traveling in different directions all of the formations ranging from the upper part of the Ordovician to the middle of the Pennsylvanian were studied in the field in a comparatively inexpensive way. The practical value of such teaching is shown by the number of recent graduates who have secured desirable professional positions as teachers and investigators of geology.

C. S. P.

GENERAL INSTRUCTIONS.

A EQUIPMENT.

Each student should provide himself with a note book, an outline of field trips, a pocket ruler and a pocket lens. Either the National or Ward's note book is convient. A foot ruler may be purchased as cheaply as ten cents, and a lens as low as twenty-five or forty cents. Agricultural and Civil Engineering students should purchase lenses which they can also conveniently use in Botany and Civil Engineering, respectively. Each section should have a number of hammers. Topographic maps (5 cents each) of the region visited are very desirable, and a collecting bag very convenient.

B COLLECTIONS.

A sample of each mineral found on these field trips should be collected and properly labeled. Likewise a small sample of each lithologically different rock should be collected and labeled. A number of the most abundant and most characteristic fossils of the different formations should be collected, and at least their generic names learned. All of these specimens should be preserved for further study.

C REPORTS.

Notes should be taken fully and accurately as indicated in the outlines, and from your own observations. From these a neatly written report should be made and handed in not later than one week after the trip. It should include description, sections drawn to scale, and diagrams. Photographs also add to the attractiveness of the report, but are not required.

Symbols for the various kinds of rock to be represented in the sections may be seen on the inside of the back cover of any of the Folios of the U. S. Geological Survey. In writing the report, follow the major divisions of the outline; but, since the minor divisions are arranged according to their occurrence in the field, rearrange them according to their proper sequence.

Read the outline for each trip carefully just before the trip is taken.

MARBLE CLIFF.

A Location.

Marble Cliff is on the east side of the Scioto River about four miles northwest of the Capitol. The principal quarries are north of the Pennsylvania Railroad bridge.

The quarries may be reached direct by the Columbus, Urbana & Western Interurban, or if the Arlington city car is taken, by walking from the end of the line west on Fifth Ave. to the river road and thence north. (Round trip ticket including city fare, 10 cents via Arlington line).

B Physiography.

I. The Olentangy River Valley.

- a Note the size of the stream as compared with the width of the flood plain and size of the valley.
- b Examination will show the valley to be cut quite largely in drift ~~or~~ and rather soft shale.
- c At the west bank near the Arlington line notice the gravel bank of rather large pebbles. This is outwash material from the glacier, probably at the time it was building the recessional moraine at Powell.

II. The area between the Olentangy and Scioto Rivers.

- a An area three or four miles wide and 120 to 150 feet above the Olentangy.
- b The eastern portion composed quite largely of drift as well records show.
- c Field study and the Dublin sheet will show that it is practically an unmodified till plain without a definite divide.

III. The Scioto River Valley.

- a A rather large stream in a small valley with only a small flood plain, and this developed only in places.
- b The lower strata of the valley are hard limestone.
- c When the hard limestone formed the bed of the river it meandered back and forth, cutting a rather wide valley. When it became so deeply entrenched in the limestone that it could no longer overflow the walls of the gorge, then the former bed and flood plain became a terrace—a destructional or structural terrace.

C STRATIGRAPHY.

Smith and Price Quarry.

I. Columbus limestone.

- a Note that the color of this and the overlying formation is very similar in the quarry face. This is due to weathering and the length of time it has been subjected to these agencies may be determined by the size of the trees growing on the piles of debris. Determine the color of a freshly broken surface, and then state if the color change is sufficient to be a serious detriment to a good building stone.
- b The planes between two adjacent layers are called bedding planes, and are due to a change in the sediments, or to a change in the rate of deposition. Supposing that one foot of sedimentation occurs in 1000 years,* measure the intervals and determine the

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*Williams, H. S., Geological Biology, 1895, p. 57.

length of time it must have taken for each of a number of different layers to form.

c The more or less vertical fissures are joints. Determine whether they are major or minor joints, and whether they are dip or strike joints. Measure and record their trend. Mention the importance of bedding planes and joints in quarrying.

d Stylolites. This is sometimes called "hackle tooth" structure. It consists of fluted columns arranged perpendicular to the bedding planes. When broken at right angles to the bedding it somewhat resembles the sutures of the brain.

e Smooth horizon. Its origin has been attributed to glaciation, wave action and horizontal jointing. After careful examination give the points in favor and against these, and state which you think is the more probable.

f *Spirifer acuminatus* zone. This zone frequently contains quite a large number of these Brachiopod shells which have a broad, deep furrow, and a high acuminate fold. Locate the horizon.

g Coral Zone. *Diphyphyllum verneuilanum* (Edwards and Haime). This zone is frequently filled with a composite coral. The individual corallites are cylindrical, and about the size of one's finger. Recall the conditions under which corals grow, and think of the change of conditions from that age to the present time.

h Bone bed. The Devonian period is known as the age of Fishes. At the close of the Columbus some sudden change took place which killed a large number of these fish, and the fragments of their remains are found rather abundantly in the very top of the formation.

i Section. Now begin at the base of the exposure, measure and record the various intervals of the Columbus, say from the base to the smooth horizon, from the latter to the *Spirifer acuminatus* zone, from the latter to the coral zone and from the latter to the top of the formation.

II. Delaware limestone.

a Note the decided change in the thickness of the layers.

b Examine freshly broken surfaces and determine the color, and whether or not a change of color occurs at the same horizon as the change in bedding. Note the odor.

c Measure and examine the thin zone of shale at the base. We shall learn more about this zone on a subsequent trip.

d Note the abundance of chert in thin nodular layers, and look up its origin in the text.

e Since there are no zone markers, measure the complete thickness of that portion of the Delaware exposed here, bearing in mind that the upper portion has been swept away.

III. After drawing and describing in your report the section just measured, sum up briefly the geological history of the region.

Casparis and other quarries.

Farther up stream at the crushers are the old quarries of the Casparis Stone Company, while on the opposite side of the river are their new quarries. Above and below the Pennsylvania tracks and opposite the Smith and Price quarries are still other quarries.

In the various quarries determine the contact between the Columbus and Delaware, by means of bedding and color. Then strengthen your determinations by locating the bone bed, the coral zone, the *Spirifer acuminatus* zone and the smooth horizon.

D ECONOMIC GEOLOGY.

I. Building stone.

a Columbus limestone.

It is used for complete structures, as the State Capitol. It is more frequently used for range work, steps, door and window sills and caps.

II. Furnace flux.

a The upper part of the Columbus is used extensively for furnace flux, the purer portion containing over 90 per cent. of calcium carbonate.

III. Fertilizer.

a The finely ground material of the Columbus is used for fertilizer of clay soils and in the manufacture of glass.

IV. Manufacture of glass.

a The finely ground Columbus is also used in the manufacture of glass.

V. Railroad ballast and road metal.

a The Columbus and the Delaware limestones are both crushed for these purposes.

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FISHINGERS—SLATE RUN.

A LOCATION.

Fishingers (Bridge) is located on the east side of the Scioto River about 5 miles northwest of the State House, and about one-eighth above the storage dam. It is reached (round trip ticket 25 cents) by the Columbus, Urbana and Western Interurban, which terminates at this point. About half a mile above the bridge is an old quarry below the road, and 200 yards further up stream the Delaware is exposed at the east road. A mile and a half above the bridge is the Columbus Fishing Club's pond in the lower part of Slate Run.

B PHYSIOGRAPHY.

I. Scioto River Valley.

- a Estimate the height of the different terraces above the river, also their length and width, and state whether they owe their existence to constructional or destructional processes.
- b When the surfaces of these terraces formed the bed of the stream, all of the loose material was swept away down to the solid bed rock, Delaware limestone. Ground water has leached out the calcium and magnesium carbonates, leaving behind the chert. Note that the broken fragments of chert constitute a considerable proportion of the soil. The residual clay of the soil owes its red color to iron.
- c Compare the width of the inner rock gorge with that of the river itself.

II. South Branch of Slate Run.

- a Explain why the blue clay at the bottom is so compact and so jointed.

- b Note that the upper drift is not so firmly consolidated and that it contains a large amount of pebbles and boulders.
- c Describe the beautifully planed and striated bowlders—some of Ohio shale—in the bed of the stream, and account for their large number.

III. North Branch of Slate Run.

- a Note the undercutting taking place in the Delaware limestone at the bend in the stream.
- b Compare the width of that portion of the valley in the limestone with that in the shales and explain.

C STRATIGRAPHY.

Old quarry below the road.

I. The Columbus limestone.

- a Determine the upper limit of the formation by the change in bedding and in color.
- b Confirm your determinations by locating as many as possible of those zones studied at Marble Cliff.
- c Measure and describe the formation.

II. The Delaware limestone.

- a Note that the slate-like, brown shale at the base is fossiliferous and collect an *Orbiculoidea* — a circular or disc-like shell — and a *Lingula* — a spade-like shell. Read what Professor Whitfield said about this Inarticulate Brachiopod fauna.
- b Measure this brown shale and compare its thickness with that of the same shale at the Smith and Price Quarries.
- c Notice how the shales grade rather insensibly into the shaly limestone and chert above.
- d Complete your measurement and description.

At the second east-road.

I. The Delaware limestone.

a Examine the reddish or rusty color of the limestone and explain its origin.

b Near the level of the terrace, locate the zone of button-like corals — *Hadrophyllum d'orbignyi* Edwards and Haime — and collect some of them.

On the river road.

I. The Delaware limestone.

a Compare the bedding and chert with previous exposures.

b Note the brown shale at the base.

c Determine the contact with the Columbus.

Slate Run.

I. The Columbus limestone.

a Since the smooth horizon is easily identified, locate and describe it.

b Note the presence of a second smooth horizon and explain.

c Describe the joints.

d Measure up the proper distance and locate the bone bed, after which begin the section.

II. The Delaware limestone.

a Locate and measure the slate-like brown "Marcellus" shale. Prove your identification by collecting the various fossils of the Inarticulate Brachiopod fauna.

b Examine the contorted zone and suggest how it may have been formed. Compare your conclusions with Professor Miller's.

c Locate the chert zone.

d Complete the measurement of the formation and determine its complete thickness.

III. The Olentangy shale.
  a Determine its color, hardness, and whether it is argillaceous (clayey) or arenaceous (sandy) by taking small particles between the teeth.
  b Examine the thin zones of brownish or blackish hard shale and the occasional thin layer of impure limestone.
  c Measure its thickness.

IV. The Ohio shale.
  a Compare this shale with the Olentangy with respect to color, hardness, and resistance to weathering.
  b Describe the difference between a fresh and a weathered piece of Ohio shale, and the difference between layer and lamina.
  c Study the joints and determine whether or not they occur irregularly or in systems.
  d Locate the small anticlinal fold at the point where the Olentangy passes beneath drainage.
  e Carefully study the concretions and determine whether they were formed before or after the shale. Does the evidence suggest a growth from circumference to center or vice versa? Make a diagrammatic sketch of a concretion and the adjacent shales in your report. Some of these iron stone concretions contain calcite crystals which readily dissolve out of the matrix, leaving excellent examples of differential weathering.
  f Notice an occasional fragment of plant remains, and suggest the origin of the coloring matter in the shale. Of what are similar shales, slates, and schists of the Proterozoic indicative?

V. Briefly sum up the geological history of the region as revealed by the stratigraphy and physiography studied.

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ROCKY FORK.

A LOCATION.

Rocky Fork is an eastern tributary of Big Walnut Creek, entering that stream just below Gahanna. This village is about ten miles northeast of Columbus. It is reached by the Columbus, New Albany and Johnstown Interurban. (Round trip tickets 30 cents).

The first exposure is reached by walking east to the iron bridge, the second in the stream just beyond the cross roads. The remainder are found along the stream between this and the covered bridge, from which place the diagonal road offers the shortest route back to the village.

B PHYSIOGRAPHY.

I. Area between Alum and Big Walnut creeks.
  a Sections along Alum and Big Walnut creeks and elsewhere show that this region is covered with drift—a till plain. Observe how level the area is and that it is practically unmodified by erosion. Such regions are said to be in youth.

II. Big Walnut Creek.
  a Compare the size of the stream with the width of the flood plain, and with the width of the valley.
  b In these respects compare the stream and valley with those of the Scioto.

III. Rocky Fork Creek.
  a At the iron bridge notice the rather large flood plain.
  b Above the cross roads note the meandering of the stream, and suggest the reason. Also locate the cut offs, ox-bow lakes, and other deserted channels.

- c Just north of the present valley is an "island hill" and around this is an old valley. Study the outline of this on your topographic sheet and suggest its origin.
- d Just above the suspension bridge is an old valley filled with glacial material. In the bottom is a blue compact clay supposed to be old drift. Above is loose, stratified sand and gravel capped by ordinary till, both of later age. After examining this material sketch and describe it. State briefly in your report the succession of events.
- e Note the width of the valley as you pass farther within the limits of the Berea formation, and compare it with the valley above the Berea.

IV. Along the diagonal road.

- a Study the drift sheet as you return.
- b Note the depression, *kettle,* in the drift on the left of the road, and explain how it was formed.

C STRATIGRAPHY.

Iron Bridge east of Gahanna.

I. Ohio shale.

- a Compare the exposure with that on Slate Run, and state the essential differences.
- b Examine the joints and show how they materially aid in widening the valley when the stream undercuts.
- c Locate the calcareous layer of cone-in-cone, and sketch its structure.
- d Measure the section.

Exposure above cross roads.

I. Ohio shale.

- a Explain why the layers of shale differ so markedly from those previously studied.
- b Measure the trend of the two systems of joints, stating their relation to each other, and to the strike and dip.
- c Locate the upper contact and measure this interval.
- d Here the top is 800 feet above sea level, while at Slate Run, 12 miles to the west, the base is at approximately the same level. The dip is 30′. Compute the thickness of the formation.

II. Bedford formation.

- a Determine the hardness of the shale and whether it is argillaceous or arenaceous.
- b Locate the fossiliferous zone near the base and collect at least a Pelecypod, small clam-like shell. Look up the geographical distribution of this fossiliferous zone.
- c Note how the numerous vertical joints break up the layers of shale into small squares or rectangles, and how these aid the frost in producing talus. Formerly the streams washed the base of this cliff in a large bend and removed the talus as fast as it fell. Joints and frost are thus important factors in the widening of valleys.
- d Determine the different colors of the shale by breaking it and examining the fractured edges.
- e Complete the measurements.

III. Late Wisconsin drift.

- a Examine the heterogeneous mass and note that it rests disconformably upon the Bedford.

At the Suspension Bridge.

I. The Bedford shale.

- a The base of the exposure under the bridge is approximately the same as the top of the exposure of Bedford in the last section.
- b Determine the color of the shale as before, and measure its thickness.
- c The red and blue colors of these argillaceous shales are significant. Ferrous compounds, ferrous oxide (FeO) and ferrous carbonate ($FeCO_3$), like metallic iron have a strong affinity for oxygen, and on exposure to the air become oxidized just as iron rusts. The FeO unites with the O directly and the $FeCO_3$ first gives off the CO_2 as a gas and then unites with the O; both forming ferric oxide, either hematite (Fe_2O_3) or limonite ($2Fe_2O_3 3H_2O$).

  These products are the great insoluble coloring agents, red and yellow respectively, of nature. When, however, these ferric oxides come in contact with decomposing organic matter, the latter, because of its greater affinity for oxygen, reduces the ferric oxides to ferrous oxide (FeO). The ferrous oxide then readily unites with the carbonic acid (CO_2) of the meteoric waters, and the soluble ferrous carbonate, siderite ($FeCO_3$), is the result. The ferrous compounds impart a bluish or grayish color to the rocks.

Now the soil which furnished the sediment for the fine clayey Bedford shale was exposed for long periods, and the iron compounds probably all became oxidized, thus imparting their red and yellow color. If swept into the sea at not too rapid a rate they would become reduced in the presence of decomposing organic matter to ferrous compounds, and thus color the sediment blue. If, on the other hand, the rate were too rapid, or the organic matter too small, all would not be reduced, and some of the sediments would be colored red or yellow.

The Tree Cliff.

I. The Bedford shale.

- a The base of the exposure is about eight feet above the top of the last Bedford interval.
- b Note the change in color and lithology and the presence of some slightly thicker layers.
- c Just above the Tree Cliff the shales are badly folded or crumpled. Note that this disturbance does not affect the Berea and suggest the reason.

II. The Berea formation.

- a Note the contorted layer of sandstone at the base and give its two limits of thickness.
- b The shaly interval is inaccessible, but is argillaceous below and arenaceous above.
- c Complete the section by measuring the sandstones above.

Gorge section.

I. The Bedford formation.

- a Examine the shales which are near the creek level.

II. The Berea formation.

- a Note the great changes in the lowest (5 inch) layer as you trace it up stream. With what would you correlate it?
- b Measure and compare the thickness of the shaly interval with the same interval in the Tree Cliff, and determine if composed of both argillaceous and arenaceous material.
- c Note the change in thickness of the layers as you ascend.
- d Determine the top and then measure the complete thickness of the formation exposed in this section.

III. The Sunbury shale.

- a Compare it with the Berea, the Bedford and the Ohio.
- b Measure the amount exposed and describe it.

The Upper Gorge section.

I. The Berea formation.

- a Examine carefully the excellent ripple marks. Determine whether or not their trend is the same in all of the layers and ascertain their direction.
- b Determine the texture of the sandstone.
- c From its texture and structure, the sandstone has been referred to both off shore and land origin.

II. Sunbury shale.

- a Study the shale carefully and then state how you can distinguish it from the Ohio.
- b Collect, either here or at the covered bridge, the *Orbiculoidea* and *Lingula* fauna near the base. Count the number of these occurring on one square inch and then compute the number for just one square mile.

D ECONOMIC GEOLOGY.

- I. Shales for the manufacture of brick.
    - a The Bedford shale is used in the manufacture of brick and like products at Taylors, two miles south of this place.
- II. Building Stone.
    - a In the northern part of the state, the Berea is extensively used as a building stone.
- III. Abrasives.
    - a The Berea is also extensively used in the manufacture of grindstones, in the northern part of the state. In fact Ohio produces more abrasives from this formation than is produced in the remainder of the United States.
- IV. Oil.
    - a The Berea becomes an important reservoir for oil in the southeastern part of the state.

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LITHOPOLIS AND VICINITY.

A LOCATION.

Lithopolis is a small village about fifteen miles southeast of Columbus. It is reached by neither steam nor traction line. Both the Hocking Valley Railroad and the Scioto Valley Traction line, however, pass through Canal Winchester, its nearest station. (Round trip tickets 50 cents. If thence by livery add 40 cents each for ten or more).

Drive or walk south on the Lithopolis — County-line — road to Little Walnut Creek bridge. Here is the first exposure. Then continue on this road until you cross Lithopolis Run just before reaching the village. Exposures are found up this stream as far as the quarries, or, even as far as the cemetery.

B PHYSIOGRAPHY.

En route to Canal Winchester.

I. Carefully observe the stratified drift on the east side of the car at Steelton.

II. Note that these deposits culminate in Baker Hill. The cut of the Lockbourne road together with the gravel banks along its sides show that the hill is composed mostly of stratified drift, whose planes of stratification are in the utmost confusion.

III. Note the extreme levelness of this region, which is either a till or an outwash plain. State which.

IV. Observe the low ridge a mile beyond the Big Walnut Creek bridge.

En route to Lithopolis.

I. Notice the rather sharp demarcation of the Little Walnut Creek flood plain.

- II. Carefully study the profile and rounded sweep of these glaciated hills, and on first occasion compare them with the angular ones of the non-glaciated region.

C STRATIGRAPHY.

Little Walnut Valley.

- I. The Ohio shale.
  - a Determine the color, bedding, hardness and kinds of joints.
  - b State briefly but clearly how you would determine whether this is Ohio or Sunbury shale.

Lithopolis Glen.

- I. The Bedford formation.
  - a The base of the exposure in the glen is about 60 feet above the top of the last exposure. Measure the thickness of the shale in the bank and then compute about where the lower limit of the formation should be drawn in the 60 foot covered interval.
  - b Determine the kind of shale and then compare it with the upper interval on Rocky Fork.
  - c Note that the upper surface is uneven.
- II. The Berea formation.
  - a Note that the base of the Berea is also uneven, that is, it rests disconformably upon the Bedford.
  - b Determine the texture and the color of a freshly broken surface.
  - c Locate the few horizons of ripple marks.
  - d Determine the iron mineral in the top of the stratum, and explain its effect on the sandstone.

- e After measuring the formation, and recalling its thickness on Rocky Fork, describe briefly the two conditions which produced this change, bearing in mind (a).

III. The Sunbury shale.

- a If the water in the bed of the stream will permit, prove your indentification by collecting the two Inarticulate Brachiopods, *Orbiculoidea* and *Lingula*.
- b Determine the color, bedding, and hardness of the shale.
- c After determining the approximate top, measure the formation.

IV. The Cuyahoga formation.

- a Note that the first interval is composed of shales. Determine the kind and thickness.
- b Examine the next interval which is a rather thick layer of argillaceous sandstone.
- c Note the texture, color, and thickness of the sandstone layers, the color and kind of shales, and the relationship of the shales to the sandstone. These lower 50 or 60 feet probably constitute the Buena Vista member, and because the sandstone works so readily it is called "freestone" by the quarry-men.
- d Examine the upper surface of a number of the layers in search of the mud flows and worm trails.
- e Note the predominance of shales above the Buena Vista member.
- f After completing the measurements, state briefly the conditions or change of conditions under which the Cuyahoga was deposited.
- g Examine carefully the texture of the blocks of sandstone by the road side near the ceme-

tery. Compare the sandstone with your samples of Cuyahoga.

D ECONOMIC GEOLOGY.

I. Building stone.

a Certain layers of the Buena Vista sandstone are quarried in the Leyndecker Quarry for building stone. Measure these different layers, examine the texture, and look for the presence of iron. Compare the color of the fresh stone with the color of the same layer in the quarry face, and then state its desirability as a building stone.

b West of Portsmouth this member is quarried to a large extent, although the quarries are without railroad facilities.

LITHOPOLIS TRIP CONTINUED FOR THE DAY.

Drive southwest from Lithopolis to the same county-line road, then drive south on the county-line road half a mile and turn east into the first lane. Big Run receives two tributaries from the east at this point. The south one is Smith Run and the north is Hartman Run.

A STRATIGRAPHY.

Smith Run.

I. The Bedford shale.
  - a Determine the kind and hardness, and the color in the different parts.
  - b Carefully study the upper surface of the shales noting whether or not the layers are horizontal and if they are cut across.

II. The Berea formation.
  - a Note the uneven base of this stratum and name the structure.
  - b Obtain the two extremes in thickness and compare them with the measurements of the same formation in Lithopolis Glen and on Rocky Fork.
  - c Note the presence of iron sulphide at the top and observe the effect of this upon the stone.

III. The Sunbury shale.
  - a Determine its color, hardness and texture.
  - b Collect a number of *Orbiculoidea* and *Lingula* in the zone near the base.
  - c The base and top are beautifully shown within short distances from each other. Carefully measure the thickness.

IV. The Cuyahoga formation.

  a Determine the kind of shale in the shaly interval and measure its thickness.
  b Observe that the next zone is sandstone, and composed apparently of two layers. Determine their texture and thickness.
  c Study the sandstones and shales above, and complete the measurement.
  d Notice how some of the layers have been arched by frost action.

Hartman Run.

I. The Cuyahoga formation.

  a Descending the stream study the sandstones and shales.
  b Measure and study the sandstone zone near the base.
  c Determine the kind and thickness of the basal shaly zone.

II. The Sunbury shale.

  a Study the shale and measure it at this place.

III. The Berea formation.

  a Measure the blocks of sandstone and compare it with the same sandstone in Smith Run.

IV. The Bedford formation.

  a Compare the shale with that in the last section.

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NEWARK AND VICINITY.

A Location.

Newark is about thirty miles east of Columbus at the point where North Fork from the north, South Fork from the south, and Raccoon Creek from the west, unite to from the Licking River. Besides numerous Pennsylvania and Baltimore and Ohio trains, the Ohio Electric cars reach Newark every hour. (Round trip tickets by electric $1.10).

B Physiography.

En route.

I. Note the short gravel ridge, esker, just east of Big Walnut Creek. Briefly discuss the different ways of esker development.

II. Carefully notice the small sags and swells about Kirkersville. These are terminal or more properly recessional moraines, and were formed during halts in the final retreat of the ice sheet. State why they have this peculiar development rather than a ridge-like one.

About Newark.

I. The Old Newark Valley.

a Note the heights of the various terraces above the rivers and their composition. The valley was filled with glacial material to the top of the highest, but the present river has removed all of this to its present level, except the portion which forms the terraces. In your description state whether they are primarily constructional or destructional features.

- b Estimate the width of the valley and compare your estimate with the width shown on the Newark sheet. This old valley extends toward the east to Hanover, Trinway and beyond.
- c The Muskingum River flows west through the old valley to Trinway, and there leaves it and turns to the south. The Licking flows east in it as far as Claylick when this stream also forsakes the old valley and turns toward the south into a gorge. Between these two places a small insignificant creek meanders slowly toward the east.
- d Well records show that there is a filling of 235 feet of drift in the old valley at Newark, and that the floor rises toward the east. State briefly the direction of the former drainage before the changes occured.

II. From Bald Knob, carefully study the rounded glaciated hills of the region.

C STRATIGRAPHY.

Small gully on the south side of the valley just east of Quarry Run.

I. Cuyahoga formation.

- a Note the relation of the shales and sandstones and briefly describe the conditions of deposition.
- b Examine carefully the irregular upper surface, state in what two ways it could be formed and which is the more probable, and what the structure is called.

II. The Black Hand formation.

- a Note the uneven base and the small ironstone concretions.

  - b Carefully examine the texture of the sandstone and then say whether it was deposited in a transgressing or receding sea, basing your conclusions upon I b.
  - c After sketching the contact complete the section.

Stasels Cliff, one-eighth mile farther east.

I. Cuyahoga formation.
  - a Determine where the contact occurs in the 75 foot covered interval above the river level.

II. Black Hand formation.
  - a Examine the bedding and texture of the lower portion.
  - b The next eight or ten feet is "Conglomerate I" of Professor Herrick. Examine and describe carefully, noting especially the cementing material.
  - c Examine the texture of the upper part, and collect some of the Crinoid stems. These are marine animals. After completing the section briefly sum up the conditions of deposition during the Black Hand age.

Quarry Run.

I. The Cuyahoga formation.
  - a Compare with the same formation in the Gully section.
  - b Note that at various places in the stream the Paleozoic rocks are not exposed, but instead, the later, Pleistocene, bowlder clay.

II. The Black Hand formation.
  - a Compare with the lower portion in the last two sections.
  - b Locate "Conglomerate I" below Haven's Quarry, and if possible find a Brachiopod

and Crinoid fossil in it. Then clearly explain their significance under the conditions of deposition.

c Measure the basal layers in the quarry and use the proper adjective in describing their thickness.

d Geologists describe the upper eight or ten inches of the last of these layers as friable sandstone. Examine and explain.

e From the shale zone secure a Pelecypod shell belonging to the genus *Allorisma* after which the zone was named.

f The next interval is a layer of grit, "Conglomerate II," forming the top of the Black Hand. Locate and describe.

III. The Logan formation.

a Describe the shaly zone.

b Collect a number of fossils from the lower sandstones and then determine whether the sandstone is of fresh water or marine origin.

c Compare the bedding in the lower and upper parts of the formation as exposed in the quarry. Note the color and its resistance to the changes produced by weathering, and then complete section.

d The base of the upper portion exposed along the highway is about —— feet above the top of the quarry. Describe this portion and note that the upper contact is not well shown.

IV. The Maxville limestone.

a This limestone is due at this horizon, but is wanting here. Explain the two conditions under which this could occur.

V. The Pottsville formation.

- a Describe the Sharon conglomerate which is only partially exposed near its base.
- b In the field note the horizon of a seam of coal.
- c On Bald Knob collect from the abundant fauna in the fragments of Lower Mercer limestone. Explain the significance of the color of the limestone and of its fauna.
- d Complete the section.

VI. Briefly sum up the complete geological history of the region from your own study.

D ECONOMIC GEOLOGY.

I. Building stone.

- a The Black Hand sandstone has been quarried to some extent in this vicinity, ex. Haven's Quarry.
- b It is more extensively quarried, however, along the Hocking Valley south of Lancaster.

II. Glass sand.

- a The Black Hand is quarried and crushed for a glass sand at Black Hand.

III. Oil and gas.

- a Derricks of oil and gas wells can be seen from the car window before Newark is reached. These obtain their supply from a sandstone in the Clinton formation, about 2000 feet below the surface.

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ZANESVILLE.

A Location.

Zanesville is located at the confluence of the Licking and Muskingum rivers, about fifty-five miles east of Columbus. It may be reached from Columbus by either the Baltimore and Ohio Railroad, or the Ohio Electric. (Round trip by electric $1.90.)

B Physiography.

En route.

I. From the car window carefully study the terraces on the north side of the valley for five or six miles east of Newark. Note whether they rise from or descend toward stream level as you pass down the valley. Illustrate by sketches and explain. Also draw one or two cross sections of the valley showing the different terraces using the topographic sheet if necessary.

II. Examine the topographic sheets, Newark and Frazeysburg, and note that the Licking River leaves the "Old Valley" near Hanover, and passes through *The Narrows* to Black Hand. As you ride through the gorge compare it with your conception of it gained from the maps. Note the limited space available for railway construction on either side of the stream. Notice, also, that there was not sufficient room for the canal, so that it was necessary to construct a dam at Black Hand and utilize the river through the gorge. Estimate the height of the walls of Black Hand conglomerate. Check your estimate with the map. Make a cross section and compare it with the former one.

III. Note the island hill, Black Hand rock, after which the formation was named. The quarry at this place crushes the rock for glass sand. Note the changes in drainage at this point.

IV. From the car and the map, notice the greater width of the valley below Black Hand and explain.

At Zanesville.

I. The city of Zanesville is one of the oldest towns of the state. What was probably the greatest factor in its early settlement? It is also the Ohio terminus of the Zanesville and Maysville (Ky.) Pike. Note the approximate equidistance from the Ohio River of the towns through which this pike passes.

C STRATIGRAPHY.

Putnam Hill.

I. The Lower Mercer limestone.

a If the water is sufficiently low, examine this limestone in the river beneath the Y-bridge. Determine its color and from your collection of fossils, state whether it is of fresh or salt water origin.

II. The Upper Mercer limestone.

a Determine its color, lithology of the lower and upper portions, and its origin.

b Measure the dip of the layers at this place and estimate the interval between the two strata of limestone.

III. Interval of shales and sandstones.

a Measure and examine the shales to the covered interval.

- b Nearer the railroad bridge locate and carefully study the erosion plains, fault plains, and the polished surface of some of the fault plains.
- c The covered interval ends at the level of "Dug Way" and completes the Pottsville formation.

IV. The Brookville coal.

- a Measure and study the thin stratum of bitumous coal and shales. This stratum with the under clay and shales beneath forms the base of the Allegheny formation.

V. The Clarion coal.

- a Study this thin stratum of bitumious coal with under clay and shales below.

VI. The Putnam Hill limestone.

- a Determine the color of the various parts and state to what the color of the upper portion is due.
- b State whether it is of marine or fresh water origin.
- c Locate the fault in this limestone, and measure the throw and heave, and state whether it is a normal or thrust fault. Sketch this in your report and label all of the various parts.

VII. Interval of shales and sandstones.

- a Examine and measure the shales and sandstones to the top of the hill.

VIII. The Upper Putnam Hill limestone.

- a Locate this stratum at a point farther south.
- b Determine its color, origin, and thickness.

IX. The Lower Kittanning, No. 5, coal

- a Locate this horizon by a dark stain, "blossom", at a still higher horizon and still farther south.

X. The Middle Kittanning, No. 6, coal.
  a Locate this horizon by means of the old opening which has now fallen in.

XI. The Lower Freeport sandstone.
  a Examine the shales and sandstones to the extreme top of the hill.
  b Note that the various members of the different formations do not completely make up the whole, but instead mark only definite horizons, thus leaving numerous intervals undesignated.

Zanesville Stone Company's Quarry.

I. The Homewood sandstone.
  a Note that the color is partially due to the small flakes of a certain mineral. Determine what one.
  b Measure one or more of the massive layers and compare them with the thickest layers you have studied.
  c Study the thin zone of more friable sandstone at the top of the member. Sketch and describe the root-stems contained in it. Locate the soil in which they grew and explain.
  d The last zone marks the top of the Pottsville formation as well as that of the Homewood member.

II. The Brookville coal.
  a Examine the thin stratum of bituminous coal with its thin zone of under clay.

III. Interval of shales.
  a Determine the color and whether the shale is argillaceous or arenaceous, or both.

- b Search the lower portion for fossils and state how these differ from the ones collected thus far.

IV. The Clarion coal.

- a Locate the dark streak of bituminous matter, "blossom", which probably represents this horizon.

V. The Putnam Hill limestone.

- a Describe the limestone and compare it with the same stratum along the "Dug Way".

VI. Briefly but accurately sketch the geological history of the region as revealed by your study. Especially keep in mind the fossils of the limestone, the erosion plains, the coal and the fossils of the Allegheny shales.

D ECONOMIC GEOLOGY.

I. Construction stone.

- a The Homewood is quarried for constructional purposes.
- b Compare the color of the stone in that portion of the quarry now being worked with the older portion.
- c Examine the texture of the sandstone and estimate the amount of water absorption, or if possible determine this amount. State the importance of this in a building stone.

II. Coal.

- a The Middle Kittanning, No. 6, coal is mined to a considerable extent in this vicinity. Look up the importance of this coal in Ohio.
- b If in driving an entry in the No. 6 coal a fault plain was encountered from the hade side, state whether the entry should be con-

tinued on a lower or higher level, basing your answer on the fault already studied.

III. Clay products.

  a The shales and fire or under clays of the Pennsylvanian series are quite extensively used in the manufacture of brick and pottery in this city.

  b They are also the source of a thriving pottery industry at Roseville and Crooksville, twelve or fifteen miles south of Zanesville.

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CEDARVILLE, CLIFTON, YELLOW SPRINGS, AND GOES STATION.

A LOCATION.

Cedarville is located on Massies Creek about fifty miles southwest of Columbus. It is reached by the Miami Division of the Pennsylvania Railroad. (Round trip about $2.00.) Clifton is at the head of Clifton Gorge in the Little Miami River, and about a four-mile drive northwest from Cedarville. Yellow Springs, in turn, is a similar drive west from Clifton, while Goes Station is south of Yellow Springs. (Carriage about 50 cents.)

EN ROUTE.

A PHYSIOGRAPHY.

I. Observe the level till plain between Columbus and London.

II. Study plates II and XI of Monograph XLI of the U. S. Geological Survey by Leverett before taking the trip. Then from the car window note the coalesced portion of the first, second and third recessional moraines of the Late Wisconsin drift sheet, between London and South Charleston.

III. In a similar manner study the terminal moraine of the Late Wisconsin at Selma.

IV. Compare the Early Wisconsin drift sheet between Selma and Cedarville with the one just passed over. State which is the more eroded and which is the more conspicuous.

CEDARVILLE.

A PHYSIOGRAPHY.

I. Note the narrow gorge of Massies Creek within the town itself. The rocks of its walls belong to the massive Cedarville limestone.

II. Study the old abandoned valley below town, and state whether the change occurred in pre-, inter-, or post-glacial time. The rocks of its sides also belong to the Cedarville. After a study of the structure of the three or four formations exposed here, suggest a possible cause for the desertion of this channel.

B STRATIGRAPHY.

I. The Osgood shale.

  a Examine the few feet of shale exposed at the base of the section on the north side of the stream and then describe its color and texture.

II. The West Union limestone.

  a Measure and describe this stratum of limestone.

III. The Springfield limestone.

  a Study the structure of this limestone. Compare it with the limestone above and below and state whether it throws any light on the change in drainage.

  b Determine whether or not it is fossiliferous.

IV. The Cedarville limestone.

  a Study this limestone and state how it differs from the Springfield.

  b Locate the zone of abundant fossils. Collect the larger Brachiopod shell, *Pentamerus oblongus* Sowerby.

- c Note the differential weathering which produces the "honey comb."
- d Collect a small sample of the limestone and in the laboratory, determine its variety.

C ECONOMIC GEOLOGY.

- I. The Cedarville limestone.
  - a From your study of this limestone in the gorge, state whether or not it would make a good building stone. Give your reasons.
  - b Note the quarry in this limestone within the town itself and the purpose for which it is quarried. Besides its extensive use in this county (Greene), it is similarly utilized in Clark and Montgomery counties.
- II. The Springfield limestone.
  - a From your study discuss the facility with which this limestone could be quarried.
  - b Would you recommend its color?
  - c At Springfield it occurs in thin regular layers with a buff color, and is extensively quarried for a building stone.

CLIFTON.

A PHYSIOGRAPHY.

- I. Observe the width and depth of the Little Miami Valley in the drift above the Cedarville limestone.
- II. Compare the width of the valley at the last place with that of the same stream below the village.
- III. Note the deposit of travertine on the walls of the gorge. This is calcium carbonate, $CaCO_3$, precipitated from solution by the escape of carbon dioxide gas, CO_2.

IV. Observe the increase in width of the valley where the river has penetrated to the depth of the Springfield limestone. Explain.

V. "Steamboat rock" is a large block of Cedarville limestone, which was precipitated into the stream when the undercutting of the Springfield reached a vertical joint in the Cedarville. Determine the relation of its present to that of its original position. Estimate the minimum age of "Steamboat Rock."

B STRATIGRAPHY.

I. The Springfield limestone.

a Note the color of a freshly broken surface and compare it with that of the face of the cliff.

b Determine the maximum and minimum thickness of the thin layers of limestone.

c State whether or not it is fossiliferous.

II. The Cedarville limestone.

a Measure the thickness of the limestone, which is practically one layer. At the rate of one foot in a thousand years, compute the time required for its deposition.

b Locate and collect the large Brachiopod fossil, *Pentamerus oblongus* Sowerby. Note their abundance, and that they are the internal impression or mould of the shell. Explain the process of fossilization in this case.

YELLOW SPRINGS.

A PHYSIOGRAPHY.

I. Observe that the town is located on the west side of an old valley.

II. The spring within the park.

- a Note the large hill of travertine deposited by this spring.
- b Besides the calcium carbonate the spring water contains iron carbonate, siderite, $FeCO_3$, in solution and is therefore a chalybeate spring. When it reaches the surface the siderite changes to an insoluble oxide, and is therefore precipitated, imparting its color to the travertine.
- c Examine the fossil leaves, twigs, etc. These are impressions or more precisely, incrustations.

III. Pompey's Pillar.

- a Observe that the pillar was produced by differential weathering.
- b Note the differential weathering exhibited by the West Union, Springfield and Cedarville limestones within the pillar itself.

B STRATIGRAPHY.

I. The Osgood shale.

- a Locate the shale in the lower portion of Cascade Run.
- b Describe its lithological characters.

II. The West Union limestone.

- a Measure the stratum above the Osgood and compare this with its thickness farther up stream at the lower falls.

III. The Springfield limestone.

- a Measure the interval of thin layers of limestone.
- b Note the presence of a few *Pentamerus* and other fossils.

IV. The Cedarville limestone.
  a Measure and compare its bedding with that at the previous places.
  b Locate the zone of *Pentamerous oblongus* Sowerby at the base and collect some of them.

GOES STATION.

A PHYSIOGRAPHY.
  I. Note the southerly extension of the old valley.
  II. Observe the variations in the terminal moraines of the early Wisconsin sheet. They are in part from the Scioto lobe and in part from the Miami lobe.

B STRATIGRAPHY.
  I. The Richmond formation.
    a The Elkhorn (?) member.
      1 Examine carefully the lithological character of the lower part and especially the color.
      2 Likewise study and describe the upper part, which is called the Belfast beds.
  II. The Clinton limestone.
    a Note the bedding.
    b Describe the texture and color.
    c Describe the fossil contents.
    d Measure the thickness of the rocks exposed in this section.

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BIG AND LITTLE DARBY CREEKS BETWEEN GEORGESVILLE AND WEST JEFFERSON.

A Location.

Georgesville is located at the confluence of the Big and Little Darby creeks, twelve miles southwest of Columbus. West Jefferson, on the other hand, is located on the west bank of the little Darby about the same distance west of Columbus, and about four miles above Georgesville.

The Little Darby exposure is on the south side of the stream at the sharp bend about a mile above Georgesville. The Big Darby exposure is on the west side of the creek at the end of the lane which terminates at the Madison-Franklin county line.

The Big Four Railroad passes through Georgesville, and the Ohio Electric through West Jefferson. The trip may be made by going either route and returning the other, or by using the Big Four in both directions. (Single trip ticket 25 cents.)

B Physiography.

I. Observe the level till plain between West Columbus and Georgesville.

II. Notice the outwash gravel, modified drift, in the railway cut east of Georgesville.

III. Note the short but high ridge of stratified drift at the bridge.

IV. Compare the size of the streams with the width of their flood plains, and observe the terraces of the Little Darby.

V. Study the post-glacial gorges or channels of the Big and Little Darby creeks, and determine their age by the length and development of their tributaries.

C STRATIGRAPHY.

The Little Darby Creek section.

I. The Monroe limestone.

- a Determine the color of the limestone.
- b Study, sketch, and describe the peculiar appearance of the layers of limestone.
- c Examine the dark bands in the layers and determine their odor from freshly broken surfaces.
- d Notice how much more closely the one or two layers of hard, crystalline, brownish limestone resemble the Columbus than they do the other layers of their own formation.
- e Carefully study and describe the upper surface of this formation.

II. The Columbus limestone.

- a Note the change in color, bedding, texture, and hardness from that of the Monroe.
- b Examine the uneven base with its basal conglomerate. State whether or not the pebbles are of the same lithological appearance as the Monroe, and if the same, whether they were derived from fresh or weathered specimens. In your description state whether this is a disconformity or an unconformity.
- c Collect and carefully study samples of the red clay which is the residue left after the carbonated ground waters have dissolved away the calcium carbonate, and state to the presence of what it owes its color. Determine the hardness of the nodules left in the clay and then explain why they have escaped solution.
- d The porous or spongy crystalline mass on the face of the limestone is of more recent age. When carbonated ground waters, H_2O

and CO_2, bearing limestone, $CaCO_3$, in solution reach the surface, carbon dioxide, CO_2, is liberated and calcium carbonate, $CaCO_3$, precipitated. Name and describe this deposit.

The Big Darby Creek section.

I. The Monroe limestone.

  a Determine if the color is the same here as in the last exposure, and if freshly broken pieces give the same odor.
  b Sketch the structure of a number of layers of limestone.
  c Locate the fossilized hopper-shaped crystals of salt, and explain their climatic significance.
  d Examine the uneven upper surface.

II. The Columbus limestone.

  a Note its color, hardness, bedding, and texture.
  b Carefully study the basal conglomerate.
  c Collect the coral fauna from the red residual clay and explain why these fossils were not dissolved with the limestone.
  d Near the fishing cabin collect a sample of the long prismatic crystals of calcite.

III. Write a brief but complete geological history of the region as revealed by your study. Bear in mind that the Monroe is probably the equivalent of the Salina and the Columbus of the Onondaga and that between the two, in New York State, occur ten formations. After the Monroe was deposited beneath the sea it was raised to a land surface and subjected to erosion, while ten formations were being deposited in the east. Then its uneven surface was submerged to receive the Columbus limestone. In other words this disconformity represents a hiatus of sufficient magnitude to cover the long lapse of time required for the slow development of ten formations.

D ECONOMIC GEOLOGY.

I. Lime.

a The Monroe is a magnesian limestone and is burned for quicklime at Greenfield. It is also used for the same purpose in the northern part of the state.

II. Building stone.

a The Monroe occurs in regular layers of medium thickness at Greenfield, and makes an excellent building stone.

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DEEP RUN.

A LOCATION.

Deep Run is a small tributary which the Olentangy River receives from the east at a point about two miles north of the Franklin-Delaware county line, or, ten miles north of North Columbus. The Columbus, Delaware and Marion Electric line crosses the run at stop 42, about a mile above its mouth. (One way fare from North Columbus 20 cents.)

B PHYSIOGRAPHY.

Deep Run has carved its valley in the eastern slope of the Olentangy River valley. In its descent it passes through, in order, the drift, the Ohio shale, the Olentangy shale, the Delaware limestone and the Columbus limestone. The difference in hardness of these various strata has given rise to a rather large number of physiographic forms. The valley will now be studied: —

I. In the drift.

- a Note the width of the valley as compared with the size of the stream, and explain why the ratio is such. Show this in a cross section sketch.
- b Locate the former meanders, ox-bow lakes, cut-offs, and other similar features, and explain why the stream is now so straight.

II. In the Ohio shale.

- a Compare the width of the valley here with its width in the drift. Sketch it.
- b These bends in the stream are known as *entrenched meanders*. Explain how they were formed.
- c Note how the stream undercuts the shale on the outside of the bend, and this with the

presence of two systems of joints permits whole columns of shale to slide into the stream and be swept away during the next freshet.

III. In the Olentangy shale.
  a Explain the change in the width of the valley at this place. Draw a cross section.
  b Note that the side streams do not enter at grade. They seem to hang upon the sides of the main valley and are called *hanging valleys.* Explain why they were developed.
  c The deposits at the mouths of the tributary valleys and against the walls of the main valley are *alluvial fans* or *alluvial cones.* Notice that they occur in the steepest portion of their respective channels and explain how deposition occurs here, and not in the more gentle slopes.

IV. In the Delaware and Columbus limestones.
  a Notice the width of the valley as compared with that of the former places and state the cause of the change. Sketch a cross section.
  b During a portion of the year the stream disappears at the limestone. Explain how it reaches the Olentangy River, and state whether or not such conditions are numerous in limestone regions.
  c Note the delta formed by this swift (during freshets) stream in the more sluggish Olentangy.

C STRATIGRAPHY.

I. The Columbus limestone.
  a Determine its color, bedding, etc.
  b Collect from its abundant fauna.

c At the Olentangy Park the lower part of the Ohio shale is at water level, while at Stratford, just below Delaware, the top of the Delaware limestone forms the bed of the river. Name and orient the structure that would give you twenty feet of the Columbus and all of the Delaware at this point midway between those just named.

II. The Delaware limestone.

a Carefully examine the base, which is a massive, brown, fossiliferous limestone. This may be the indurated representative of the Marcellus shale at Fishingers and Slate Run. Does the section of freshly quarried stone opposite the Casparis crusher support this view?

b Locate the fault and if possible measure the amount of displacement.

c Notice the contorted appearance of the zone of alternate layers of chert and limestone.

d The top of the stratum reveals what is probably a local dip.

III. The Olentangy shale.

a Determine the kind of shale.

b Notice the concretions in almost definite layers. In the laboratory determine the mineral composition from a small sample.

IV. The Ohio shale.

a Determine the color, hardness, and kind of shale.

b Examine the two systems of joints. Determine their trend and state their relationship to each other.

c The large iron-stone concretions were formed by successive accumulations about some nucleus. In other words their growth was from center to circumference. Give the evidence that they were not formed in cavities and that their development was subsequent to the deposition of the shale.

d Search for the much smaller concretions of pyrite and marcasite. Note and sketch their rather fantastic outlines.

e Notice the efflorescence on the face of the cliffs. Taste it.

V. The Drift.

a Determine the great range in the size of the material composing the drift.

b On the south side of the valley about 300 yards below the electric line, examine the drift carefully. Rather large blocks of Ohio shale are mixed with finer material and with bowlders of hard igneous rock, showing that the blocks of Ohio shale have been moved but a short distance else they would have been ground to pieces.

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BLACKLICK TO REYNOLDSBURG.

A Location.

Blacklick is a small village located about ten miles east of Columbus where the Pennsylvania Railroad and the Baltimore and Ohio Railroad cross Blacklick Creek. Reynoldsburg is located on the same stream nearly three miles south of the former place, and at the point where the Ohio Electric crosses the creek. (Fare, steam 20 cents and electric 15 cents).

B Physiography.

I. Note the comparatively narrow valley of Blacklick Creek where the walls are composed of Cuyahoga rock.

II. Study the structure of the stratified, Pleistocene, clay with its covering of unstratified till at the point where the western wall of the valley disappears.

III. Observe how the valley broadens and becomes indefinite beyond this point where the material is all drift.

IV. Now consult the topographic sheet and note the influence of the topography of this stream upon the direction of the railroad.

C Stratigraphy.

Quarry below track.

I. The Cuyahoga formation.

a Determine the texture of the sandstones and their relationship to the shales.

b Note the color of the stone in the quarry face and compare it with that of a freshly broken surface. Is it a desirable building stone?

- c Some of the layers are broken up into rectangular or cubic blocks by two systems of joints. Note how these blocks have their corners and edges rounded by the elements until they roughly resemble concretions or bowlders. Draw a cube whose edges are one yard in length, and then subdivide it into secondary cubes whose edges are one foot in length. Let the weathering of the secondary cube in the center of one of the faces of the primary cube equal unity. Now express the amount of weathering the secondary cube in the center of one of the edges of the primary cube, and the one at one of the corners of the larger cube will undergo in a similar period. Then explain why these blocks weather to rounded masses.

East bank ¼ mile down stream.

- I. The Cuyahoga formation.
  - a Locate the thick layer of sandstone nine or ten feet above the base of the formation. What is its texture?
  - b Examine the shales below the sandstone.
  - c Compare the last two intervals with the basal portion of the same formation exposed in Lithopolis Glen.
- II. The Sunbury shale.
  - a Determine the color, texture, and kind of shale.

In Reynoldsburg.

- I. The Cuyahoga formation.
  - a Note that there are two layers of thick sandstone.
  - b Examine the shales above and below the two layers of sandstone.

II. The Sunbury shale.

  a Study this shale as before.

III. This sandstone along Blacklick has been referred to the Berea grit and the black shale below to the Ohio. Give your reasons for calling them Cuyahoga and Sunbury.

D ECONOMIC GEOLOGY.

  I. Building stone.

    a The Cuyahoga is worked in the Wm. A. Forrester quarry to the northeast of Reynoldsburg for building purposes.

REFERENCES.

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Orton: Cuyahoga basal shales referred to the Bedford. Ann. Rept. Secy. State for 1879, 1880, p. 594.

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MT. PERRY TO FULTONHAM.

A Location.

Mt. Perry and Fultonham are located about 45 and 50 miles, respectively, east of Columbus. Both villages are situated on Jonathan Creek, and on the Zanesville and Western Railroad, which is operated by, and connects with, the Toledo and Ohio Central Railroad, at Thurston. The Ohio Central enters only the West Broad street station. (Round trip a little over $2.00.)

B Physiography.

I. Notice the exceedingly level till plain from Columbus to Pickerington.

II. The Pickerington esker extends for 5 miles southeast from Pickerington on the north, or left side of the railroad. Study this ridge as far as possible from the coach window.

III. Note that Jonathan Creek valley grows narrower and narrower from Thornport (Thornville station) until it terminates in a gorge between Mt. Perry and Fultonham. Consult the topographic sheets and notice the direction from which the principal tributaries enter Jonathan Creek in this portion of its course. State what these features suggest to you, and then read pp. 165 to 173 of Vol. XI, Bulletin Scientific Laboratories of Denison University.

C Stratigraphy.

First cut below Mt. Perry iron bridge.

I. The Logan formation.

a Determine the texture and color of the sandstone and its proportion to the shale.

- b In the north wall notice the uneven upper surface of the formation, and measure the greatest variation in thickness in the shortest horizontal distance. (Use the track as a base level.) Since the layers are horizontal explain the cause of this irregular surface.

II. The Pottsville formation.

- a Notice the thin stratum of bituminous shales and coal resting disconformably upon the Logan. Briefly state the difference between an unconformity and a disconformity.
- b Next examine the shale and especially note the bedding of the conglomerate. Name this structure and the conditions under which it was formed. All of these constitute the Sharon member.

III. Sketch the structure shown here, on a larger scale than it is possible to do in your regular section.

Ravine just below the Mt. Perry iron bridge.

I. The Logan formation.

- a Determine the texture of the sandstone and shale.
- b From the same base level, carefully measure the Logan and briefly state the significance of this change in thickness.

II. The Maxville limestone.

- a Notice especially, that instead of the Pottsville resting directly upon the Logan, this stratum of limestone occupies that position.
- b Examine the limestone carefully, paying particular attention to its bedding, composition, and color.

III. The Pottsville formation.
  - a Study the thin ferruginous layer resting disconformably upon the Maxville.
  - b Note the shales and sandstones above, and state whether or not you would expect such a variation in sediment in so short a distance. Why?

The Second, Third and Fourth cuts.

I. The Logan formation.
  - a Compare it lithologically with the Logan in the previous exposures.

II. The Maxville limestone.
  - a Again study the bedding, composition, and color.
  - b Note the somewhat gradual change from the Logan sandstones and shales to the Maxville limestone, causing the line of contact to be somewhat arbitrarily drawn. Does the statement that the Logan seems to have been worked over either before or after consolidation by the transgressing Maxville sea explain the condition of deposition?

The Fifth Cut.

I. The Maxville limestone.
  - a Note that the base of the formation is not exposed. If possible locate a familiar zone and compute from your previous records the depth of the base below track level.
  - b Again note the massive lower portion and its composition.
  - c Carefully study the three-foot zone of nodular limestone alternating with shale. This zone divides the formation into a lower half consisting of massive indefinite layers, and in-

to an upper half made up of medium definite layers. Collect a number of the abundant fossils found in this zone.

- d The upper half at this place consists of but a single layer. In other exposures farther down stream the number increases, then decreases and thus varies from place to place. Measure these variations and note how the irregular upper surface cuts across the horizontal layers. Also explain why the individual layers project from the face of the cliffs.

II. The Pottsville formation.

- a Again study the thin zone of iron ore and its relationship to the layers of limestone beneath.
- b Examine the exposed remainder of the Sharon member.

D ECONOMIC GEOLOGY.

I. Building stone.

- a The Maxville was formerly quarried at Fultonham for this purpose. The court house at Zanesville was constructed from stone quarried near White Cottage.

II. Lime.

- a The Maxville was formerly burned for quicklime at Maxville, Ohio, Limeville, Ky., and, on a small scale, at a number of other places. Better shipping facilities, however, have permitted other limestones to supplant it.

III. Furnace flux.

- a During the days of charcoal furnaces in southeastern Ohio, it was used in a number of places for flux. A revival of this slumbering industry would undoubtedly again create a demand for this stone.

IV. Cement.

a Prof. Orton's tests of the Maxville from Fultonham and White Cottage show that this would make an excellent stone for this purpose.

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DOANVILLE (MYERS CROSSING STATION).

A LOCATION.

Doanville is located at the confluence of Monday Creek and the Hocking River about three miles below Nelsonville. The Hocking Division of the Hocking Valley Railroad passes through Nelsonville, where it is necessary to transfer to a train of the "Branch" Division. (Single trip ticket $1.35. By purchasing Lancaster twin tickets round trip will be about $2.15.)

B PHYSIOGRAPHY.

Aboard the train.

I. Note the sags and swells, hummocky appearance, of the recessional moraines in the vicinity of Lockville and Carroll.

II. Sugar Grove is on the glacial boundary line. Compare the somewhat rounded profiles of the hills before reaching that place with the more angular ones beyond.

III. Outwash material from the glacier filled the valley of the Hocking River to a height of 80 feet or more. Subsequent stream erosion has removed most of this, but remnants are left as "constructional" terraces at a number of places.

a The high school in Logan is located on one of these.

b The terraces on the north side of the valley between Logan and Smith Chapel and at Smith Chapel belong to this class.

c On the south side one is seen at the Children's Home.

C STRATIGRAPHY.

- I. The Middle Kittanning coal, No. 6.
  - a Study this coal both in the mines and in natural outcrops.
  - b Measure the various divisions of coal and shale and ascertain the names applied to them by the miners.
  - c Learn how far above the base the machine undercuts the coal and how it is blasted down with powder.
  - d Determine whether or not fossil ferns occur in the shales above the coal.
- II. The Lower Freeport sandstone.
  - a Determine the color, texture, and thickness of this member which occurs just above the No. 6 coal.
- III. The Upper Freeport coal, No. 7.
  - a If possible study this coal which is due 60 to 95 feet above the No. 6.
- IV. The Mahoning (lower) sandstone.
  - a Note the bedding, texture, and color of this sandstone which occurs only a few feet above the No. 7 coal.
- V. The Cambridge limestone.
  - a This limestone should occur at from 75 to 100 feet above the No. 7 coal.
  - b Collect a representative fauna from it and in the laboratory compare the fossils with those from the Mercer limestone. Since the members of the Pennsylvanian series are very inconstant, save these thin limestones and a few of the coals, the ability to recognize the limestone is highly desirable. These fossils greatly aid in this indentification.

- VI. The Ames limestone.
    - a Locate this limestone in the top of the hills. It is about 80 to 90 feet above the Cambridge, about 300 feet above the Middle Kittanning coal and 200 above the Upper Freeport coal.
    - b Determine the abundant fossil after which it was named. Also search for other forms.
- VII. Briefly sum up the geological history of the region.

D ECONOMIC GEOLOGY.

- I. Coal.
    - a The Middle Kittanning coal, No. 6.
        - 1 This is the great seam of the Hocking Valley Coal Field which includes portions of Athens, Perry and Hocking counties.
        - 2 Look up the location and number of mines in these counties on the state geological map of 1909.
        - 3 Ascertain the most important use of this coal.
    - b The Upper Freeport coal, No. 7.
        - 1 This member is the best developed in the Cambridge field which includes portions of Guernsey and Noble counties.
        - 2 Likewise study the location and number of mines in this field.
        - 3 Since this coal does not endure transportation well its principal use is for steam purposes.
- II. Clay products.
    - a The Kittanning (Lower and Middle) horizon.
        - 1 This is usually a white plastic clay but sometimes a very refractory fire clay and occasionally a flint fire clay.

2 Sometimes the lower clay is separated from the upper by the Lower Kittanning coal alone and then the two may reach 50 feet in thickness.

3 It is said to be more valuable than all of the other horizons in Ohio combined, and the usual variety is the basis of the pottery industry over much of eastern Ohio.

4 Note the three or four brick yards near Nelsonville and the large tile plant at Haydenville, all of which utilize these clays.

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